Counting the Ocean's Greenhouse Gas Emissions

A new database seeks to improve estimates of oceanic emissions of methane and nitrous oxide.

Ocean surface photographed directly from above. Credit: Shutterstock/anmo

By Annette Kock and Hermann W. Bange 10 February 2015

To understand how Earth's climate will change in the future, scientists need to know how much heat-trapping gas is going into the atmosphere today. However, oceans' emissions of two major greenhouse gases, methane (CH_4) and nitrous oxide (N_2O), vary dramatically in time and space. With a centralized digital resource, the Marine Methane and Nitrous Oxide (MEMENTO (https://memento.geomar.de)) database, information on CH_4 and N_2O concentration measurements from around the globe are collected to help researchers more precisely quantify these oceanic emissions.

Oceanic CH_4 can arise from shallow sediments, and both CH_4 and N_2O are produced by ocean-

dwelling microbes. Although only a relatively small fraction of global CH_4 emissions—around 2%—come from the ocean (including coastal areas), oceans are a major source (http://www.nature.com/nature/journal/v396/n6706/abs/396063a0.html) for atmospheric N_2O, providing around 25% of the total. When it reaches the stratosphere, N_2O attacks ozone (http://www.noaanews.noaa.gov/stories2009/20090827_ozone.html), destroying it on a global scale.

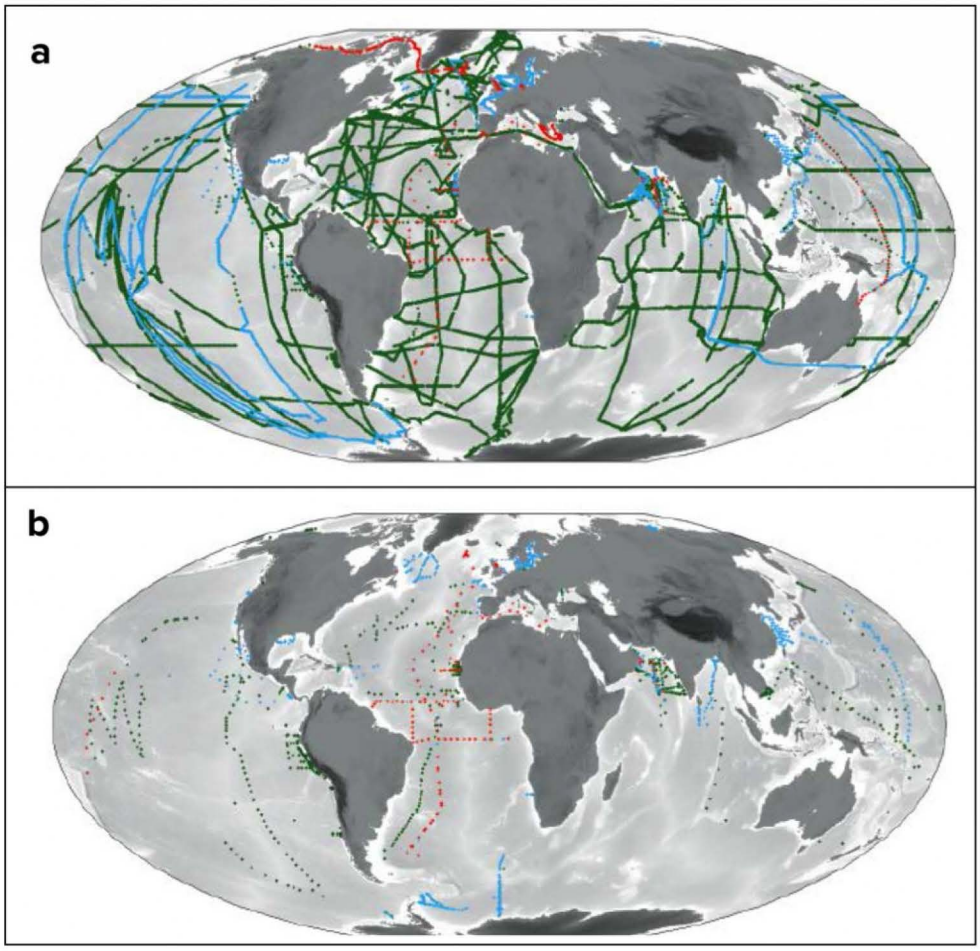
Estimates of oceanic emissions are based on extrapolations of concentrations measured at the ocean's surface or results from model studies. For example, using the data set of *Weiss et al.* [1992], *Nevison et al.* [1995] calculated the first global field of surface ocean N_2O concentrations to estimate the marine N_2O source to the atmosphere.

However, the fluxes of N_2O and CH_4 can vary substantially from day to day and from place to place, meaning that even with recent improvements in measurement techniques and increased measurements, global emission estimates are still highly uncertain [see *Ciais et al.*, 2013]. Millions of measurements taken at different times and covering the globe are needed for researchers to more precisely estimate how much gas is being emitted.

MEMENTO Ups the Game

MEMENTO, an initiative that began in 2009, is the first attempt to systematically compile all global data on oceanic CH_4 and N_2O measurements.
MEMENTO, an initiative that began in 2009, is the first attempt to systematically compile all global data on oceanic CH_4 and N_2O measurements. It archives data taken not only at the ocean surface but also from the deep ocean. As curators of the data set, our goals are to see how oceanic concentrations of the gases vary in time and space and to provide more precise global emission estimates of oceanic CH_4 and N_2O to the climate research community.

MEMENTO already includes original data from more than 180 measurement campaigns, which have provided more than 20,000 CH_4 and more than 100,000 N_2O measurements over the past 50 years (see Figure 1 for sampling locations). These data sets include dissolved gas concentrations along with information on sampling position, sampling depth and time, and, if available, data on ocean temperature and salinity as well as oxygen and nutrient concentrations.



(https://eos.org/wp-content/uploads/2015/02/Fig-1a-b_web.jpg?250acc)

Fig. 1. (a) Locations of surface and (b) depth profile (stations with sample depths greater than 10 meters) of N2O (green), CH4 (blue), and collocated N2O and CH4 (red) measurements included in MEMENTO as of January 2015.

If available, we also include atmospheric measurements from the same campaign, such as air temperature and air pressure, usually sampled a few meters above sea level height. We also add to all submissions the contact information of the researchers who provided the data, their related publications, and if available, a link to the host center of the original data sets.

An Emphasis on Quality

If measurements lack information on sampling position, sampling time, and sampling depth (for oceanographic data), we do not import them into the database.

We put all data submissions imported to MEMENTO through a systematic quality control procedure to guarantee that essential metadata are available and to minimize erroneous entries. If measurements lack information on sampling position, sampling time, and sampling depth (for oceanographic data), we do not import them into the database. In addition, we apply a first-order range check to all imported variables to exclude obviously incorrect data entries, such as negative concentrations, erroneous date formats, or data positioned over land.

CH_4, N_2O, and oxygen data are imported in their original units. In a second data-processing step, we will calculate global surface fields and depth profiles in common units. Missing temperature and salinity data will be supplied from external data sources.

A Work in Progress

We regularly update the database with newly available data sets and continuously improve it by including additional meta-information, allowing additional data formats, and implementing new data quality control criteria.

In addition, we are working closely with the recently initiated Scientific Committee on Oceanic Research (SCOR) Working Group 143 (http://www.scor-int.org/SCOR_WGs_WG143.htm), entitled "Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4." As an additional quality flag for our data, we will implement standard procedures that are developed within the working group for measuring N_2O and CH_4.

As we expand MEMENTO, we will also build on the experiences researchers have gained from existing databases such as the Surface Ocean CO_2 Atlas (SOCAT (http://www.socat.info)), the Global Surface Seawater Dimethylsulfide Database (GSSDD (http://saga.pmel.noaa.gov/dms/)), and the Halocarbons in the Ocean and Atmosphere Database Project (HalOcAt (https://halocat.geomar.de)). Specifically, we are looking to create best practices on how to structure data archives, methods for checking data quality, and ways to make data archives more user friendly.

A Resource for the Research Community

We intend for MEMENTO to serve as a living resource from which researchers can pull quality-controlled oceanic CH_4 and N_2O data for a variety of purposes. Researchers have already begun using the database to produce important results. For example, *Zamora et al.* [2012] and *Suntharalingam et al.* [2012] used MEMENTO data to model N_2O production and consumption processes on global and regional scales. *Freing et al.* [2012] used the database to compute global N_2O production rates from the in situ measurements. A list of associated publications (https://memento.geomar.de/publications) is available on the MEMENTO website.

MEMENTO data are freely available to interested users, who can access the database via the MEMENTO website (https://memento.geomar.de). We would like to expand our database, so please consider adding your CH_4 and N_2O data. Contact us (mailto:akock@geomar.de) to obtain the log-in information to the database and information on how to submit your data to MEMENTO.

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References

Ciais, P., et al. (2013), Carbon and other biogeochemical cycles, in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by T. F. Stocker et al., pp. 465–570, Cambridge Univ. Press, Cambridge, U. K.

Freing, A., D. W. R. Wallace, and H. W. Bange (2012), Global oceanic production of nitrous oxide, *Philos. Trans. R. Soc. B, 367*(1593), 1245–1255.

Nevison, C. D., R. F. Weiss, and D. J. Erickson (1995), Global oceanic emissions of nitrous oxide, *J. Geophys. Res., 100*(C8), 15,809–15,820.

Suntharalingam, P., E. Buitenhuis, C. Le Quere, F. Dentener, C. Nevison, J. H. Butler, H. W. Bange, and G. Forster (2012), Quantifying the impact of anthropogenic nitrogen deposition on oceanic nitrous oxide, *Geophys. Res. Lett., 39,* L07605, doi:10.1029/2011GL050778 (http://onlinelibrary.wiley.com/doi/10.1029/2011GL050778/abstract).

Weiss, R. F., F. A. Van Woy, and P. K. Salameh (1992), Surface water and atmospheric carbon dioxide and nitrous oxide observations by shipboard automated gas chromatography: Results from expeditions between 1977 and 1990, *Rep. SIO 92-11,* Carbon Dioxide Inf. Anal. Cent., Oak Ridge Natl. Lab., Oak Ridge, Tenn.

Zamora, L. M., A. Oschlies, H. W. Bange, K. B. Huebert, J. D. Craig, A. Kock, and C. R. Loscher (2012), Nitrous oxide dynamics in low oxygen regions of the Pacific: Insights from the MEMENTO database, *Biogeosciences, 9*(12), 5007–5022.

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